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ABSTRACT

An overview of theory and research in memory as it relates to developmental differences is offered in this paper, which is intended to provide background information for the staff of the Skills Essential to Learning Television Project (a multi-level series of video and print resources for classroom use). A model for viewing information processing is proposed, and studies that examined whether any components of the model were influenced by developmental differences are reviewed in order to explain the principles of memory processes applicable to children aged 9 to 12. Conclusions offered suggest that no major neurological differences fundamental to memory exist between children in late childhood and adults; that as children grow older they can recall greater amounts of information; and that the educator's goal should be to help students store information in semantic memory. Three principles important to memory are suggested: (1) rote rehearsal is not a guarantee to storing information in either long-term episodic or semantic memory; (2) the child must be trained to process the meaning of an item if it is to be remembered for any length of time; and (3) distributed retrieval in novel situations is instrumental in facilitating ease of retrieval. Twenty-four references are listed. (LMM)

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MEMORY: AS IT RELATES TO CHILDREN AGES 9 TO 12 YEARS

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The working paper reported here was written by Fred L. Perry, Jr. of the Institute for Child Study, Indiana University, for the Skills Essential to Learning Television Project, of the Agency for Instructional Television.

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INTRODUCTION

Prior to the late 1960's, research in memory investigated the recall and recognition protocols of adults (Neisser, 1967; Kintsch, 1970). The theories formulated from the results of such research, reflected the cognitive processes thought to be used by adults, but suggested little about those processes used by children. More recent studies (for reviews see Belmont and Butterfield, 1969; Flavell, 1970; Hagen, Jongeward and Kail, 1975; Haith, 1971; Huttenlocher and Burke, 1976) have examined whether or not memory processes found in adults are developmental. From these studies a clearer picture of the memory processes in children is beginning to emerge.

This paper will attempt to provide an overview of current theory and research in memory in a three-fold manner. First, a workable and updated theory of the structure of memory will be proposed. Such a framework will then provide a skeletal structure on which to attach a summary of current reviews and studies which elucidate age-related memory processes. The last section of the paper will examine implications of these studies for the educators of 9-to-12-year-old children.

MEMORY STRUCTURE

Until recently, the theory of information processing which dominated research on memory was the three-stage model (Figure 1) proposed by Atkinson and Shiffrin (1968). According to their theory, information first enters memory through the Sensory Register in its literal form, either as the *icon* for visual information or the *echo* for auditory information. For example, the letter "A" would be represented in the Sensory Register as an exact carbon copy. The Sensory Register can handle a fairly large amount of information simultaneously but cannot maintain it much longer than several hundred milliseconds. Because of this rapid, automatic decay process at the sensory level, no strategies exist by which images can be held in the Sensory Register (Klatzky, 1975).

Atkinson and Shiffrin (1968) contend that in order for the image to be retained, it must be transferred to another part of memory, the short-term store. Waugh & Norman (1965), labeled this phase as Primary Memory. This short-term store differs from the Sensory Register in three important ways. First, the short-term store has a very limited capacity. Miller (1965) proposed that the short-term store can hold seven, plus or minus two, items. Second, items in short-term store are not lost by way of an automatic decay process but are displaced by new incoming information. With no distractions from new information, the items in short-term store will be remembered. Finally, rehearsing an item, or repeating a small set of items, extends the amount of time it is held in short-term store.

If this item is rehearsed for any length of time it will enter into the long-term store (Atkinson & Shiffrin, 1968). As implied by the name, the long-term store retains information for long periods of time. It is very possible that once an item has entered into this store it resides there

Figure 1

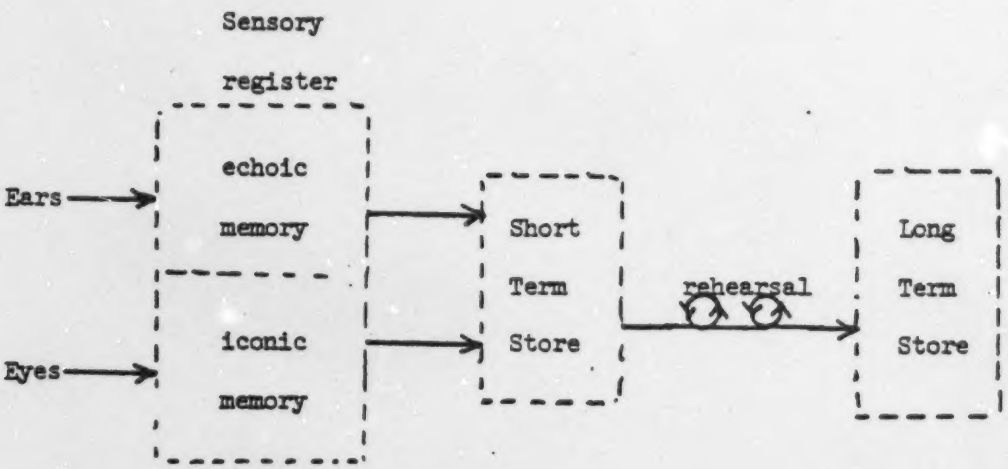

Figure 1. The three store memory model of Atkinson and Shiffrin

for the life of the individual. Not only is there no limit to the length of time information is retained, but there is no limit to the amount of information that can be remembered. Whereas the short-term store requires the deliberate use of rehearsal as a means to hold information, the long-term store needs no conscious effort for a person to keep from forgetting. However, a problem exists in retrieving the information from the long-term store. For example, when one tries to recall the name of an old friend, s/he often finds that for some reason s/he cannot remember it. In such cases the person has not forgotten the friend's name but is having difficulty locating the place in memory where it is stored.

Craik and Lockhart (1972) have challenged the adequacy of the Atkinson and Shiffrin (1968) model on three points. First of all, they note discrepancies as to the amount of information that can be contained in the short-term store. Studies using strings of unrelated words for to-be-remembered stimuli support the seven, plus-or-minus-two notion mentioned previously; however, if sentences are to be remembered, approximately twenty words can be retained.

Early thinking proposed that the short-term store held information in some acoustical form while long-term store maintained it in some semantic form (see Neisser, 1967, for a review). That is, sounds were stored in the short-term store and meanings were stored in the long-term store. Craik and Lockhard (1972) again question the earlier model, citing a number of studies which suggest that visual, acoustical, and semantic information are all stored in both short-term and long-term store. Thirdly, the manner of forgetting does not seem to be confined to three separate stores as was once thought. Craik and Lockhard (1972) cited evidence that supports the notion that rate of forgetting is affected by the type of material and

the particular task people were asked to perform. For example, real words were recalled better than nonsense words. In addition, people who were asked to use the meaning of a word remembered it better than those who were asked to make use of the word's sound, such as matching it with another rhyming word.

Rather than holding to three distinct memory stores, Craik and Lockhart (1972) proposed that memory can best be exemplified by a continuum. At one end, the most superficial transient part of memory resides where only the visual components of a stimuli are processed. The other end represents the most permanent portion of memory where meaning plays the more important role. Between the two lies the portion of memory where the sound components of the stimulus are processed. It is important to remember that these different areas of the continuum do not have distinct boundaries, but rather merge into each other. Craik and Lockhart refer to this model as the Depths of Processing Model.

From Craik and Lockhart's theory (1972) grew the notion that people used another strategy for remembering other than rehearsal; this strategy is elaboration. Rather than simply repeating a to-be-remembered item, people process the meaning of the item by relating it to a highly structured body of knowledge they already possess. The item is thus stored in a more pernament manner. Rehearsing an item, on the other hand, will hold an item in conscious memory but it will soon be lost when attention is drawn elsewhere. Craik and Watkins (1973) demonstrated that the amount of rehearsal, which simply recycles information in conscious memory in a rote fashion, facilitated immediate recall of the to-be-remembered stimuli but did not help if there was a delay from the end of rehearsal to the time of recall. They inferred from this that the length of time an item was held in

consciousness did not affect the probability of that item being stored in a more permanent manner. This would suggest, for instance, that having a student repeat some to-be-remembered item for a length of time would not help him/her remember the item.

At this point the distinction between *recall* and *recognition* should be made. Recalling an item means searching the memory for the item with little help from any cues. An example would be to ask a person to write down the lecture he/she heard an hour ago. A recognition task, on the other hand, provides the maximum amount of cues; one is asked to match what he/she sees or hears with what he/she is assumed to have stored in memory. Common examples of recognition tasks are multiple choice and true/false tests. Usually recall tasks are considered more difficult than recognition tasks because they require the use of additional retrieval strategies. That is, the learner must engage in some process which will locate the item in memory. Mnemonic devices, such as making a word from the first letter of each word in a list in order to remember the list of words, are such strategies. (Klatzky, 1975) Just because an item cannot be recalled, does not mean it has not been stored in memory. (Klatzky, 1975) On the contrary, an item may be stored in memory but irretrievable, as previously illustrated by forgetting a friend's name. In such a case a recognition task is more sensitive to what is held in memory because it bypasses the need for using any retrieval strategies (Kintsch, 1970). A learner simply tries to match the object he/she is being tested on with what he/she has in conscious, available memory.

In light of the distinction between *recall* and *recognition*, it is interesting to note that Bjork (1975) found evidence from a number of studies suggesting that an increase in the amount of rehearsal increases the probability

that one will recognize an item even though it does not affect his/her recall ability. These findings do not necessarily mean that rote repetition of an item in conscious memory causes it to be permanently stored. Rather, it seems more in line with the findings of Craik and Tulving (1975) which suggest that the longer an item is held in conscious memory, the greater the chances it will be processed semantically; that is, the meaning of the item will be attended to and related to a larger body of information one already has established in memory. It is this processing of the meaningful aspect of a stimulus which Craik and Lockhart (1972) refer to as the deepest (thus more permanent) level of processing.

In addition to the Levels of Processing Model, Tulving (1972) makes the distinction between episodic and semantic memory. Tulving categorizes as episodic information which directly relates to an actual episode experienced by a person, information which is bound within certain spatial and temporal contexts. According to Tulving, episodic memory can be of short or long duration. Comparing episodic memory to the Depth of Processing Model (Craik & Lockhart, 1972), episodic information could be processed at any level of the continuum. An example of this would be the memorization of a mathematical formula just after recess in Mr. Doe's fifth grade class. If the student was asked to solve a problem previously unseen which required the use of this formula, it is very possible that the problem would not evoke the formula in the student's memory even though the student had memorized it. However, if the student were asked to recall the formula that he/she memorized just after recess on a certain day in Mr. Doe's class, it is more likely that he/she will recall it; (assuming that he/she memorized it in the first place).

Semantic memory (Tulving, 1972), unlike episodic memory, is knowledge of the world which is not directly tied to any given context. The fact that birds fly and round things roll are instances of what most people know about the world. This type of information is permanently established in memory and is therefore more useful than episodic information. Semantic memory would involve only the deepest levels of processing if compared with the Depth of Processing Model. If the math formula mentioned above is in semantic memory, it will be evoked into conscious memory whenever any situation arises requiring its application.

It seems obvious from the preceding discussion that educators should be more concerned about getting information into semantic memory than into episodic memory. Information in semantic memory is more accessible because it can be retrieved under minimal cue conditions and more versatile because it can be evoked in a wide variety of contexts. For example, someone who has grown up on a dairy fram could write a book on a moment's notice about milk cows. The person will continually find him/herself using illustrations and examples from the farm to clarify issues that are not directly related to farming.

Although Tulving (1972) said little about how information gets into semantic memory, it seems reasonable to assume that it must go through episodic memory first. Initially an item to be remembered will be stored episodically; but as this information appears in a series of differing episodes, or contexts, it becomes abstracted into a more general knowledge system (Estes, 1975), i.e., semantic memory. If a student is to remember a piece of information in such a way that it will be easily accessible and useful to him/her in many situations, then the student must relate the item to as many meaningful contexts as possible. To illustrate how this

might be applied in a learning situation, we will return to the student trying to learn a math formula such as Y=bx+a, the formula for a line. In order for the student to analyze the meaning of the formula each symbol in the formula must take on meaning. The symbol "b" for instance is the slope of the line. The student, of course, must first learn the concept of *slope*. The formula then must be learned in as many contexts as possible, contexts which will show the student the usefulness of the formula in areas relevant to him/her. Finally, the student must apply the formula in many novel situations. This procedure forces the formula to be semantically processed, stored in relation to other information, and retrieved under new conditions. This three-fold process should be instrumental in transferring information from episodic to semantic memory.

The preceding discussion shows the partial inadequacies of the available models and reveals the need for a model of memory which incorporates these new findings. A model that attempted to account for such findings was proposed by Bjork (1975). Bjork's model as presented in the present paper has several small changes made by the author, but is essentially the one proposed by Bjork (Figure 2). At the first stage, a stimulus event (e.g. a word, a sentence, a picture, etc.) is acted on by a set of analyzers ranging from lower-order sensory analyzers which analyze the visual and acoustical components, to higher-order semantic ones which are concerned with the meaning of the stimulus. The product of the Input Analyzer System enters the Central Processor where all of the active processes take place to transform, relate, and store incoming information. The Central Processor controls whether information is either covertly rehearsed in order to simply hold it in conscious memory or to relate it to information stored in either episodic or semantic memory. The Central Processor also plays the primary role in retrieving information from the memory stores.

Figure 2

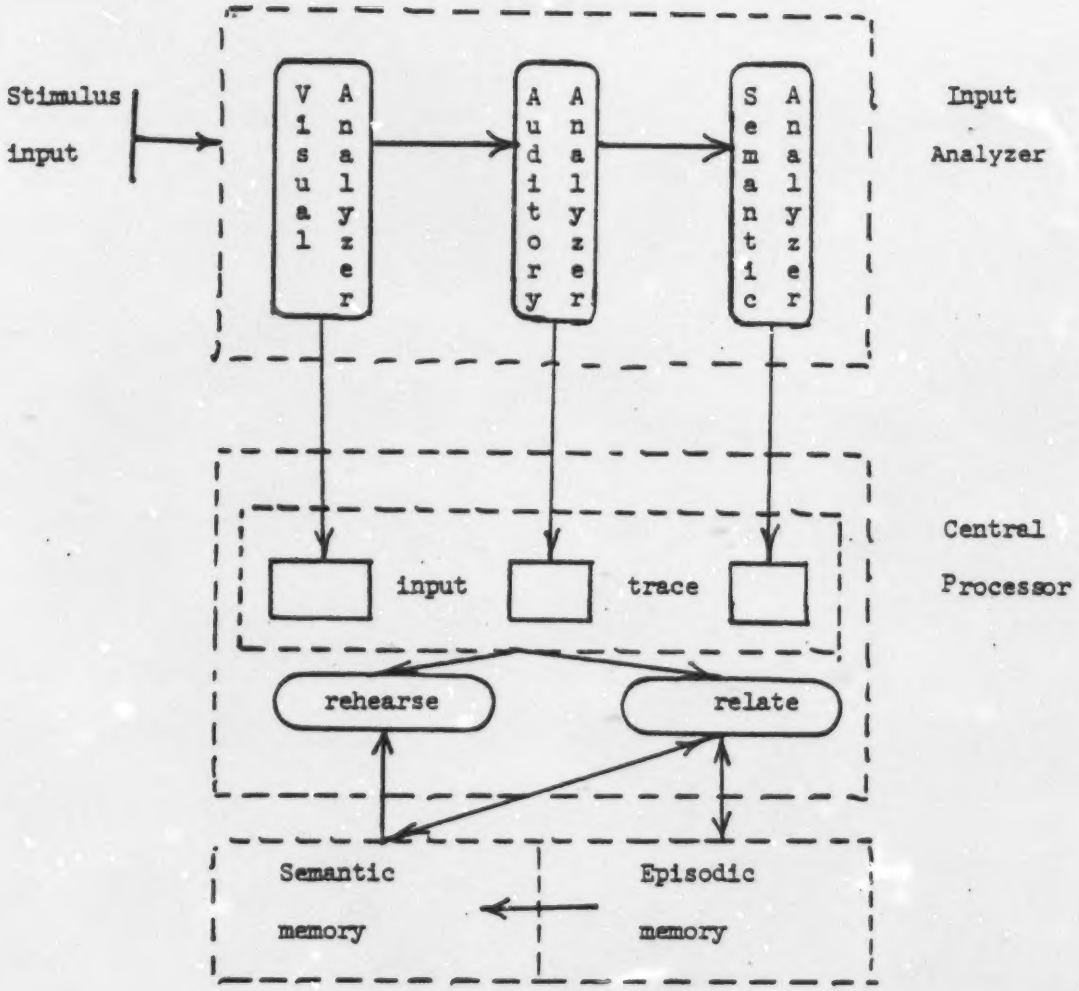

Figure 2. The revised Bjork model of memory

The Central Processor controls the Input Analyzer System by determining what aspect(s) of the stimulus is to be analyzed (Bjork, 1975). If the task is to determine whether a stimulus word rhymes with a word assumed to be stored in memory, the visual and the phonemic components of the word are analyzed at the input level. However, only the phonemic component is transferred into the Central Processor since this information is all the task requires. The Central Processor also locates the word stored in memory, extracts its phonemic component, and then attempts to match it with the phonemic representation extracted from the stimulus word. If a match occurs, the words rhyme. In essence, the Central Processor is the most important aspect of the memory system and is most likely the aspect which reflects developmental differences.

The phases of the system being proposed, then, are highly interrelated. Allowances have been made for information in the memory stores to interact with either initial encoding in the Input Analyzer or processing in the Central Processor. Having such a model permits the learner (Bjork, 1975) to be studied as an active processor of information who can either voluntarily or automatically use various strategies to remember information. The learner can choose various mnemonic devices to aid in storing information, like organizing a list of to-be-remembered words into smaller groups on some common theme. By continually using any one strategy, it becomes second nature even though at one time it required concentration. For instance, most people learned to read books by looking for and remembering the main themes, leaving the unimportant details to fade out of memory.

Before any implications of this Model to children from nine to twelve can be made, developmental differences, or differences in memory due to age, must be determined.

DEVELOPMENTAL DIFFERENCES IN MEMORY

Remaining within the basic framework of the information processing model presented above, the following discussion will look at a number of reviews of current studies concerning the development of memory. The discussion will first address the question of whether any age-related differences exist at the sensory input level (Haith, 1971) in the Sensory Analyzer. Secondly, the question of developmental differences within the Central Processor (Belmont & Butterfield, 1969, 1971; Flavell, 1970; Hagen, Jongeward & Karl, 1975; Huttenlocher & Burke, 1976) will be given the "lion's portion" of the discussion, as evidenced by the number of articles cited. The following discussion will reveal a number of counter-intuitive findings which need to be taken into consideration by anyone wishing to facilitate the retention of any instructional material, or to train individuals in the use of mnemonic strategies.

Initially (Haith, Morrison & Sheingold, 1970) it was thought that age-related differences might exist in the Input Analyzer System. This assumption was based on the finding that 5-year-old children could not remember as many items as adults in a visual recognition task (Haith, Morrison & Sheingold, 1970). A number of succeeding studies (see Haith, 1971 for a review) ruled out three possible determinants for such differential performance: time needed to perceive the stimulus, ability to detect stimuli on the periphery of the visual field, and time needed to process a visual stimulus. However, in the case of multiple stimuli, 5-year-olds took more time than older children or adults. The procedure used for examining these processes in the initial input stage of memory was developed by Sperling (1960). In this procedure, multiple stimuli were presented tachistoscopically for very short durations of time. Following the offset of the array of stimuli, a marker appeared over

the particular stimulus which the subject was to report. By controlling the duration of the stimulus onset time and the time interval between the offset of the stimulus and the appearance of the marker, various processes involved in the initial encoding of a stimulus can be precisely tested.

Sheingold (1971) also used the Sperling procedure to investigate why younger children differ from older subjects on the number of stimuli apprehended at initial input. She examined the ability of 5, 8, and 11-year-old children, and adults, to report items from an eight item array over varying delay periods between stimulus offset and marker onset. Her results revealed that everyone up to a 150 millesecond delay performed in a similar fashion. However, beyond this point the 5-year-olds' performance dropped rapidly. At the 500 millesecond delay, the 8-year-olds' performance began to decay. These findings were interpreted by Sheingold (1971) to mean that there is no difference due to age in the initial encoding processes but that differences exist once information enters into deeper areas of memory. In Bjork's Model, the Input Analyzer System does not differ across age, at least for visual features. People, regardless of their age, should be able to perceive the literal features of a stimulus. It should be noted, however, that Sheingold's study (1971) is only concerned with the visual components of a stimulus. It remains to be seen whether the other analyzers, such as the auditory and semantic ones, are also unaffected by age (see Figure 2). It can be assumed, therefore, that the difference between 5-year-olds and older subjects occurs later in the information-processing system.

According to Bjork, the next phase of this system is the Central Processor. It is at this point where the differences observed by Sheingold (1971) between 5-year-olds and older subjects have a possible explanation. Haith (1971) proposed that people as young as eight years of age have developed a strategy

which isolates the most salient parts of a stimulus, leaving the rest to fade from memory. This reduced set of features is much more manageable, and therefore easier to hold in memory, at least for 500 milleseconds. According to Haith, younger children are unable to isolate such parts because they do not know which parts of a stimulus are most important. An example would be with a learner perceiving the letter "W." A younger child may not be able to discriminate the letter "W" from the letter "M" simply because he/she has not noticed that the direction the legs are pointing in is an important feature to keep in mind. Older children have no trouble with this task because they have learned to pay attention to this feature.

In addition, Haith (1971) proposed a second strategy which could explain why 8-year-olds were not able to remember as many items as adults after 500 milleseconds. According to Haith, adults have learned to rehearse the visual icon by regenerating the visual image through a continual moving of the eyes (see Haith, 1971 for a review of several studies supporting this notion). Apparently, 8-year-olds have not learned to do this. The studies however, offer no suggestions as to how this strategy can be used for educational purposes.

Other strategies more pertinent to the learning situation have been found to be age-related. Belmont and Butterfield (1969) examined the strategies different age groups used for storing information. To do this, they devised an apparatus which could measure the length of time it took subjects to go from one item to the next in a serial learning task. A letter was flashed onto a small screen, and when the subject thought he/she had studied it enough to remember it, he/she pushed a button to see the next letter. Belmont and Butterfield (1969) assumed that the amount of time it

took for a subject to study an object reflected the amount of covert rehearsal the subject used. Their basic finding was that children rehearse items in a different manner than normal adults; however, no difference was found between normal children, mentally retarded children, and mentally retarded adults.

Belmont and Butterfield (1971) examined in greater detail the nature of these rehearsal differences across several age groups for normal and mentally retarded subjects. Their results indicated three things. First, as the number of letters to be remembered increased, adults and 13-year-olds took more time to rehearse than did normal children or the mentally retarded group. Belmont and Butterfield (1971) interpreted this to mean that normal, older groups realized the need to rehearse more so as to make each letter "stick" in memory when the number of letters they had already encountered began to get larger.

Belmont and Butterfield's (1971) second finding was that as normal subjects increased in age there was a greater tendency to spend more time processing items as the list increased in number until the last several items. At this point, the last items were processed very quickly. This is related to what has been referred to as the *primacy* and *recency effect* in remembering a list of items (Neisser, 1967). The *primacy effect* refers to the superior recall of the first part of a list of items; these first items are covertly repeated or rehearsed. For example, if someone is trying to memorize a list of fifteen consecutive items he/she is most likely to rehease all preceding items while memorizing each successive item; because the first items get the most rehearsal, they are remembered better than the rest of the list. However, if one is asked to recall the items immediately after learning the list, the last part of the list is remembered better

than the middle part: this is called the *recency effect*. This effort is apparently due to the fact that the sound of the last items are still *echoing* in the mind of the learner when he/she is asked to recall the items. Belmont and Butterfield (1971) proposed that older subjects combined a rehearsal strategy with the recency effect of auditory memory. Neither younger subjects nor mentally retarded subjects were observed to do this.

A third phenomenon observed by Belmont and Butterfield (1971) was that normal, older subjects relocated the place in the list where they spent the most time processing items. Once the subject determines the length of the list on initial trials, the maximum time of rehearsal, which was initially on the last item of the list, was relocated toward the middle of the list, leaving more of the final items to depend on auditory memory. Again, normal younger subjects and mentally retarded subjects were not observed to do this.

These three findings of Belmont and Butterfield (1971) suggest in their own words "that as people develop, they work progressively harder at tailoring their rehearsal strategies in response to recall requirements" (p. 244). It seems safe to propose, then, that as children become older they become increasingly aware of the need to implement various strategies according to what the task demands. Knowing this should aid those people who are involved in the learning processes of children 9-12-years old. Apparently, children are aware of the concept that some types of information are more difficult to learn than others. Instructors may have to indicate which components of the object being learned are the most difficult. By doing so, children can manipulate their memory strategies to focus on the more difficult components.

Although Belmont and Butterfield (1971) interpreted the length of time a subject spent on an item as reflecting a covert rehearsal strategy, one should keep in mind the previous discussion about the Craik and Lockhart (1972) notion that when the meaning of an item is processed, the item will be remembered better. It is not necessarily true, for instance, that the *primacy effect* is a result of greater rote rehearsal of information in memory. On the contrary, Huttenlocher and Burke (1976) have found evidence that rote rehearsal has little, if any, effect in producing the *primacy effect*. They observed that subjects 4, 7, 9 and 11 years old continued to demonstrate the superior retention of initial items in a list while being prevented from rehearsing the items. In addition, they found that memory span as represented by the number of items recalled in correct order increased with age.

Huttenlocher and Burke (1976) contended that the increase in span corresponding to an increase in age was based on "age-related changes in the basic processes underlying the identification for individual items" (p. 21). They reviewed a number of studies in adult memory showing that memory span increases or decreases according to the nature of the item being processed. For example, span for digits was greater than span for words, which in turn was greater than for nonsense syllables. Conrad (as reviewed by Huttenlocher and Burke, 1976) reasoned that as the number of possible items in a set increases, memory span decreases. Huttenlocher and Burke (1976) proposed that this is because of the facility with which an individual can identify and incoming stimulus. They deduced that the ease with which an item is identified is governed by the amount of attention one can give to the processing of that item in active memory, i.e., the Central Processor. Their review included a number of studies which support this notion. For example, they found that various distractions, such as background

noise, decreased the number of items remembered. They interpreted this to mean that attention from the to-be-remembered stimuli was diverted on account of the distraction, resulting in fewer items getting into memory.

Huttenlocher and Burke's (1976) reasoning may offer an explanation as to why some children remember information from materials better than other children. Children who have been frequently exposed to certain concepts will find it easier to comprehend related information than those who have had little exposure. In addition, children who have frequently used certain strategies which have proven to be effective for processing certain kinds of information will be able to process the meaning of a related learning event much faster than children with less exposure to such strategies. The more attention one gives to process an item or to determine the meaning of an item, the less attention can be given to relate the information to what they already know. As will be argued later, it is this relating process which fixes the item in memory for longer lengths of time. An example encountered in everyday life is the student who tries to read a book with either a very limited vocabulary or with poor reading habits (or both). To no one's surprise the child is not able to remember much, if anything, from the book. It is necessary, then, that a child have good encoding strategies at his/her disposal. He/she must be able to select the most relevant parts from the object being learned. At the same time, he/she must be able to relate this information to what he/she already knows.

Factors other than the amount of attention given new information are important to retaining that information and relating it to existing knowledge. The strategies used by individuals in the relating process also play an important role. These strategies have been referred to as mnemonic strategies defined by Flavel (1970) as "cognitive activities which could be deliberately undertaken for the purpose of storing and retrieving input"

(p. 193). One such mnemonic strategy is the use of verbal labels for representing pictorial information; this process is referred to as verbal mediation. For example, if one looks at a scene containing a red brick house with a tree to the east of it, one will encode the scene in the form of a verbal description when attempting to store it in memory.

Flavell (1970) reported several studies which support the notion that the spontaneous production of verbal labels for aiding the remembrance of pictorial information is age-related. The majority of the findings suggest that children under six years of age do not spontaneously produce verbal mediators (i.e., labels) to aid in memory tasks. Older children, however, were found both to produce and effectively use such strategies. These studies can provide teachers and instructors with some confidence that children by the age of nine years can make use of various mnemonic strategies.

Children, as young as 6, have also been shown to better remember information which has been organized into semantic clusters (Hagen et al., 1975). With the items in each list organized into semantic clusters such as a set of animal names appearing consecutively, followed by a set of names of various types of food, etc. The results showed that such organized lists aided the recall of items in the lists. Further findings revealed that structuring information around semantic themes decreased the chances that previously learned lists will interfere with the learning of later lists.

Hagen et al. (1975) proposed that two processes are involved in the free recall of such categorized lists. First, the semantic category itself had to be recalled. Secondly, the information subsumed by the category is recalled. Several studies reviewed by Hagen et al. (1975) suggest that children as young as six make use of category labels as cues to recall associated items. For example, if a child memorized the list: *horse, cow,*

dog, bread, meat, butter he/she should be able to recall the first three items if they were cued with the category label *animal*. However, Hagen et al. also found that only older children, ages nine and above, were able to provide the cues or category labels themselves to aid recall of the items.

The preceding findings should help educators realize the importance of organizing course materials into clear units that can be subsumed under more general semantic categories. If information in the classroom is to be remembered, then it must have some semantic structure to it. This point is accentuated by a number of studies reviewed by Hagen et al. (1975). These studies showed that when children were given a list of items which were randomly ordered, only those students older than twelve revealed any clustering strategies in the order in which they recalled the items. For example, if a child was given the list: *bread, horse, meat, jam, dog, snake* he/she should recall it in the form: *bread, jam, meat, dog, snake, horse*. The list reflects a reorganization around the semantic categories *food* and *animals*. However, Hagen et al. (1975) did find that if fifth graders (12-year-olds) were instructed to do so, they were able to reorganize items into semantic categories, thus increasing the number of items recalled.

These findings suggest that educators can help students remember information. The role of the educator should be one of training the student first to examine the nature of the task. The student must develop as second nature the ability to detect how pieces of information being learned are related to each other. Students should be instructed to use these relationships to aid in the recall of more detailed pieces of information. In addition, they must learn to constantly relate new information to that which they already know a great deal about. Educators also can train

students in knowing which mnemonic strategy is the most fitting for a particular task. Although relatively few strategies have been studied (e.g., rote rehearsal, semantic clustering, verbal labeling), whatever strategies an adult has found to aid his/her own memory for certain kinds of materials, also should aid the memory of children nine years and above.

So far, the discussion has been concerned with memory retention of an episodic nature. Indeed, until recently, major theories in memory have been based on research which had manipulated episodic variables. However, the kind of memory which seems to be more essential part of our cognitive processes is semantic. Brown (1975) defines semantic memory as "the involuntary product of our continuous interactions with a relatively meaningful environment" (p. 113). She continues by saying, "The development of memory is seen as the gradual organization and reorganization of past experience, an organizational process which is closely dependent on the structuring activities of intelligence in general" (p. 114). This concurs with Piaget's and Inhelder's (1973) notion that semantic memory is a reflection of one's schemata. A schemata, according to Piaget and Inhelder, is a highly structured system of knowledge. As an individual encounters bits of information that are relevant to his/her schemata, it is automatically assimilated into the structure. If any incongruity exists between the new piece of information and the schema, either the new item is transformed to fit the schema, the schema is revised to fit the new item, or both are changed until some point of equilibrium is reached (Piaget & Inhelder, 1973).

The existence of such a prior schema is fundamental to the integration and processing of new information. Brown (1975) summarized a number of descriptive studies which point out that various people can remember impressive amounts of detailed information if it is very closely related to

their lives. Some may suggest that this type of memory is only a result of constant rehearsal, but it seems more plausible that such retention is based on the existence of a cognitive structure into which detailed information can fit.

Age-related differences in the ability to integrate new information into semantic memory, most likely do exist simply because children's schemata increase in number and quality as they get older. For example, as the child grows, the schema associated with mathematics develops with increasing complexity. The formula for a line, y=bxta, cannot be processed meaningfully until a schema exists which relates the concepts of addition, multiplication and equality.

Although Brown (1975) defined semantic memory as an involuntary product, one should not assume that the processes involved in integrating information into semantic memory are not learned. Left to oneself, one may acquire various strategies which will transfer information from episodic memory to semantic memory. However, the quantity and quality of these strategies may be restricted to the particular environment the person develops within. It is therefore important for educators to expose students to as many kinds of strategies as possible and to help them realize that certain strategies work best for certain tasks. Unfortunately, very little research has dealt with this problem.

IMPLICATIONS AND CONCLUSIONS

The primary purpose of this paper has been to provide an overview of recent thinking in memory as it relates to developmental differences. In attempting to do so, the discussion first proposed a model by which to view the processing of information. Secondly, a number of studies were reviewed which examined whether any of the components of the information processing model were influenced by developmental differences. From this it was hoped that an explication of the principles of memory processes applicable to children ages 9-12 could be made.

Three general conclusions can in fact be made. First, all the evidence suggests that no major neurological differences fundamental to memory exist between children in late childhood and adults (Hagen et al., 1975). Children ages 9-12 years have all the neurological equipment in the Input Analyzer, the Central Processor, and long-term store needed to process and store information.

Second, the observations show that as children grow older they can recall greater amounts of information. Two factors seem to be involved in accounting for this phenomenon. The first is that as children grow older they acquire more information, either formally or otherwise. This information is not stored randomly, but rather is organized into systems of knowledge, i.e., schemata. On the bases of these schemata, children grow in awareness of what types of information are important to remember.

However, many children have memory difficulties because they do not have the schemata to relate information to, or because they have not been taught the importance of relating new information to what they already know. Very little can be done for a lack of schemata except to provide intensive remediation to establish those needed. Theoretically, children 9 years

old and older should be able to note relationships between items to be learned and what they already know. The problem is that individual differences, play an important role in whether various relationships are detectable--what might seem obvious to one child may not be to another. This process should not be left to chance; an effort should be made to train students to continually search for relationships between what is being learned and what they already know.

The second factor which may account for differential retention is the number of mnemonic strategies one has accessible to him/her at any given age. It is not sufficient, however, to simply tell a student that such strategies exist. Children in everyday life need to acquire such strategies, and in fact do when they are in situations that require them. If they fail to generate any of their own, or generate inefficient ones, then they should be exposed to efficient strategies which work best for a particular task. Again, few strategies have actually undergone research.

The third conclusion that can be made from the empirical data reviewed in this paper is that the educator's goal should be to help students store information in semantic memory. As was proposed earlier in the discussion, information first enters episodic memory; this information may either be of short or long duration depending upon how it was processed. If it only received a visual or auditory analysis, then the memory representation will be of short duration. If the meaning of the item is process, then the information will remain in memory longer.

However, this information will be in episodic memory; that is, it will be contingent on the particular context in which it was learned. If the educator only wants the student to remember a piece of information in a given context then there is no need to transfer it to semantic memory.

In many cases, however, the intention is to learn an item so that it will be easily accessible in other relevant situations. For this to happen, the piece of information must be semantically processed in various contexts which require its application. In addition, the student must be put into novel situations which require the application of the item being learned. This last procedure provides the student with an opportunity to practice retrieving the information which he/she has stored. It is this retrieval practice which makes the item easily accessible.

The empirical data reviewed in this paper suggest a number of specific principles important to memory. First, rote rehearsal is not a guarantee to storing information in either long-term episodic or semantic memory. Its primary role seems to be that of holding information in conscious memory, e.i., the Central Processor. If one needs to remember a telephone number from the time of looking it up in the telephone book to the time of dialing it, then such a strategy would prove useful. However, traditional practices such as writing a new vocabulary word down 100 times in order to enhance the memory of it, will do little more than keep a child busy.

Second, the child must be trained to process the meaning of an item if it is to be remembered for any length of time. For example, the child must first learn how the word relates to what he already knows. Finally, the word must be used in many varieties of sentences.

It is important to emphasize that the instructor is not simply to spoon-feed the student all of this information. Rather, the student must be put into situations which force him/her to cognitively process the information being learned. An example would be to have the student look up the meaning of the word in the dictionary and write its definition in his/her own words. This provides some assurance that the definition is

being semantically processed. The student then should be encouraged to produce a number of sentences varying in subject matter and style, using the new word. In case he misuses the word, he should be informed that a misuse has occurred and then be required to determine and explain why the word is not acceptable in that particular sentence. There will be times when the student cannot figure out the reason for the misuse. When this happens, the instructor should provide possible hints, but avoid explaining the full reason why the word is misused. The key is that the student be encouraged to do as much of his own mental processing as possible. One can assume that information which has been processed in such a manner has been stored in a more permanent fashion.

The third principle, distributed retrieval in novel situations, is instrumental in facilitating the ease in which an item in memory is retrieved. After passing through the initial learning stages discussed in the preceding paragraphs, the student must be put into unexpected novel situations which will require him/her to retrieve the item from memory and use it. During the initial learning stages of a vocabulary item, the student has the word both in the Central Processor and in long-term episodic or semantic memory. There is no need for any retrieval strategy to be used. However, once the word has been stored, the student needs to practice retrieving the item under a variety of relevant conditions and unexpected situations. After the student has allowed the word to leave the Central Processor by attending to some other subject matter, another unexpected situation different from the first is given to the student requiring him/her to search his/her memory, locate the item, and then use it; perhaps in a novel sentence. This process differs from rote rehearsal in that it does not let the item out of the Central Processor at any time -- it simply continues to hold a word in conscious awareness.

The preceeding discussion has been concerned with how educators can help students retain information. It is also the intention of this paper to extrapolate any strategies which can be intentionally used by the students themselves to aid their own learning strategies. As has been stated previously, there have only been a few strategies used in the research of memory: rote rehearsal, verbal mediation, and semantic clustering. Rote rehearsal is useful for holding information only as long as one needs to use it. Once the item is displaced by new information, it is forgotten. Verbal mediation is used to aid retention of pictorial information. A student who is attempting to remember a painting for an exam in an art course might want to use such a strategy. The third strategy, semantic clustering, is useful for remembering lists of items. A student might have to remember the States of the Union; to do so, it may help to cluster them according to geographical locality, or according to whether they are industrial, agricultural, or good states in which to take a vacation.

These strategies are, however, peripheral to the actual curriculum goals set up by our society. Most information required of students is not telephone number, pictures, or lists of words. Rather, rules for certain operations like mathematics or critical thinking procedures, are what is being taught in schools today. When factual information is being learned, it is with the additional goal that such information be integrated into memory in such a way as to be useful for the student, either immediately or in the near future.

Students should thus be taught strategies they can use as part of their own learning processes. They should be taught how to (1) analyze the meaning, (2) relate to relevant information one already knows, (3) retrieve for use in as many new situations as one can.

Principles (1) and (2) overlap when they are being applied to a learning situation. Students should be trained to ask themselves questions such as, "What does this new piece of information mean? Can I put the meaning in my words without using the words of the book or the instructor?" Paraphrasing is one possible tool by which a student can have some confidence that he has a grasp on the meaning. He must become aware of the notion that some form of production will help him formulate the meaning better in his mind. The student can present his paraphrase, in written form or orally, to someone who can tell him whether his response is correct.

The student should then attempt to relate (principle 2) the new information to knowledge he/she already possesses. Again, asking him several questions aids this process: "What do I already know that is related to this new piece of information?" or "Why is this information important for me to know now?" Two procedures which might help the student relate the information, and also analyze the meaning, are <u>comparing</u> and <u>contrasting</u>. The student should be encouraged to make it a habit to look for similarities and differences between what he already knows and what he is learning. Again, he should produce, either written or orally, something that reflects his comparisons and contrasts.

Principle three is another important strategy which should help the student make a piece of information easily accessible. Students need to intentionally use information that they have recently stored in as many new situations as possible. They should make it a practice to share with someone the new bits of information they have just learned — they can practice teaching the new concept to a sibling, or to a parent; or they can use a new vocabulary item in everyday conversations with friends or relatives. The point is that the new item must be retrieved from memory,

used, allowed to fade from one's conscious awareness; it should then be retrieved again to be used in another context, again allowed to fade, etc. It is not clear what actually takes place neurologically, clear pathways apparently are established between pieces of information in memory which aid the retrieval of related information (Collins & Quillian, 1972).

Ideally, educators or students should have a set of strategies they could use to enhance memory. At the moment, little research has been done to determine which strategies work best for certain kinds of materials. The strategies which have been used in research (i.e., rehearsal, clustering, and verbal mediation) have helped to clarify some memory processes, but they are related to types of material not characteristic of present educational goals. This paper has extrapolated several principles from various studies that hold promise for viable use in increasing the memory abilities of students. These strategies, however, are not the average twenty-five cent solution to improving memory, but represent procedures which will only be useful to the student who is motivated enough to exert some "cognitive sweat" in processing information. It is hoped that future research might delineate in greater detail other strategies effective in semantic analysis, in relating new information with old, and in retrieving information from memory.

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